



*Region 10, 1200 Sixth Avenue, Seattle WA 98101*

**COLUMBIA RIVER BASIN FISH  
CONTAMINANT SURVEY**

**VOLUME 1  
Appendix P**

**Summary of Risk Characterization Results  
for Anadromous Species**

**July 2002**

**Prepared by  
U.S. Environmental Protection Agency  
Region 10  
Seattle, Washington**

**Appendix P - Summary of Risk Characterization Results for Anadromous  
Species**

Six anadromous fish were sampled in the Columbia River Basin: coho salmon (*Oncorhynchus kisutch*), fall chinook salmon (*Oncorhynchus tshawytscha*), spring chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), eulachon (*Thaleichthys pacificus*), and Pacific lamprey (*Lampetra tridentata*). These fish spend a portion of their lifecycle in the ocean. Specific life history traits for each species are discussed in Appendix B.

The following sections discuss the non-cancer health effects and cancer risk estimates associated with consuming anadromous fish species for both the general public and for Columbia River Basin Native American<sup>1</sup> populations using the exposure assumptions presented in Section 4.0. Non-cancer health effects and cancer risks for resident species were summarized in Appendix O.

The methods used for this risk characterization were discussed in Sections 4 through 6 and a summary of the results are presented in Section 6. The risk characterization results shown for eggs in this Appendix are not discussed in Section 6, however, due to the uncertainty in egg consumption rates. A discussion of the risk characterization results for eggs are presented in Section 10.5 of the Uncertainty Evaluation.

Seventeen health endpoints were assessed for non-cancer health effects (Table 5-3). A total of 45 chemicals were used to generate the health endpoints ranging from one to 17 chemicals per health endpoint. A total hazard index for non-cancer health effects was also evaluated by summing the hazard quotients for individual chemicals. The 56 chemicals that have toxicity values for assessing cancer were evaluated by summing the cancer risk estimates for individual chemicals to determine a total cancer risk for two exposure durations for adults: 30 years and 70 years.

Exposure parameters were selected to estimate cancer risk and non-cancer hazards to two target populations referred to as the general public and Columbia River Basin Native Americans (Native Americans) (see Section 4.1). Within each target population, cancer risk and non-cancer hazards estimates were determined for adults, defined as individuals of age 18 or greater; non-cancer hazards were estimated for children, defined as up to age 15 years for the general public and up to age 6 years for Native Americans. Exposure parameters for adults and children differed for the fish consumption rate, body weight, and exposure duration (Tables 4-1 and 4-2). A summary and discussion of the non-cancer hazards and cancer risk estimates for these target

---

1. All references to “Native Americans” and “tribes” in this report are only applicable to the CRITFC’s member tribes: Confederated Tribes of Warm Springs, Yakama Nation, Umatilla Confederated Tribes, Nez Perce Tribe. They are collectively referred to as the CRITFC’s member tribes.

populations are presented in this section by species. More detailed information on the risk characterization results are presented in the Appendices for each fish species and tissue type analyzed in this study and for several spatial scales: site, tributary (largescale sucker only), and basin:

- Appendix G1: Hazard quotients for individual chemicals for adults
- Appendix G2: Hazard quotients for individual chemicals for children
- Appendix H1: Percent contribution from individual chemicals to the total hazard index
- Appendix H2: Percent contribution from individual chemicals to endpoint-specific hazard indices
- Appendix I1: Estimated cancer risks for individual chemicals for adults, assuming 30 years exposure
- Appendix I2: Estimated cancer risks for individual chemicals for adults, assuming 70 years exposure
- Appendix J: Percent contribution of individual chemicals to total estimated cancer risk
- Appendix M: Comparison of the total and endpoint specific hazard indices across sites for a CRITFC's member tribal child (high fish consumption rate).
- Appendix N: Cancer risks across a range of consumption rates, by site and species

## ***Appendix P-1 Coho Salmon***

Coho salmon were collected from one site in the Columbia River Basin: 30, Umatilla River. Chemical analyses were performed on egg, fillet with skin, and whole body tissue types. The risk estimates characterized in this section are based on average chemical concentrations determined from 3 replicate composite samples collected from Site 30 (Appendix A). Because one site was sampled for coho salmon, tributary and basin risk estimates were not calculated.

### **Noncarcinogenic Health Effects**

The potential noncarcinogenic health effects associated with the consumption of egg, fillet with skin, and whole body coho salmon were assessed by calculating hazard quotients for all detected chemicals with oral reference doses (Appendix G). The hazard quotients of chemicals with the same health endpoint were summed to calculate endpoint-specific hazard indices. In addition, the hazard quotients of all detected chemicals were summed to calculate a total hazard index for the site. Table 1.1 shows the total hazard index for each of the target populations evaluated in this risk assessment and the health endpoints which had hazard indices at or above 1.0.

**Table 1.1 Total hazard indices and noncarcinogenic health endpoints with hazard indices at or above 1.0 for coho salmon. Collected from Site 30, Umatilla River**

CONSUMPTION RATE/ TISSUE TYPE		HEALTH ENDPOINT	Hazard Index
<b>General Public - Adult<sup>a,b</sup></b>			
AFC	E	Total HI	0.2
AFC	FS	Total HI	0.3
AFC	WB	Total HI	0.3
HFC	FS	Central nervous system	2.4
		Immune system	2.6
		Reproduction/ development	2.4
		Total HI	5.7
HFC	WB	Central nervous system	2.1
		Immune system	2.9
		Reproduction/ development	2.1
		Total HI	6.2
<b>General Public - Child<sup>a,b</sup></b>			
AFC	E	Total HI	0.1
AFC	FS	Total HI	0.3

CONSUMPTION RATE/			
TISSUE TYPE		HEALTH ENDPOINT	Hazard Index
AFC	WB	Total HI	0.3
HFC	FS	Central nervous system	3.0
		Immune system	3.3
		Reproduction/ development	3.0
		Total HI	7.3
HFC	WB	Central nervous system	2.7
		Immune system	3.7
		Reproduction/ development	2.7
		Total HI	7.9
Native American - Adult <sup>c,d</sup>			
AFC	E	Total HI	1.3
AFC	FS	Central nervous system	1.1
		Immune system	1.1
		Reproduction/ development	1.1
		Total HI	2.5
AFC	WB	Immune system	1.3
		Total HI	2.8
HFC	FS	Central nervous system	6.5
		Immune system	7.0
		Reproduction/ development	6.5
		Total HI	16
HFC	WB	Central nervous system	5.8
		Immune system	7.8
		Reproduction/ development	5.8
		Total HI	17
Native American - Child <sup>c,d</sup>			
AFC	E	Immune system	1.2
		Total HI	2.3
AFC	FS	Central nervous system	1.9
		Immune system	2.1
		Reproduction/ development	1.9
		Total HI	4.7
AFC	WB	Central nervous system	1.7
		Immune system	2.3
		Reproduction/ development	1.7
		Total HI	5.0
		Total HI	15
HFC	FS	Cardiovascular	1.9

CONSUMPTION RATE/ TISSUE TYPE		HEALTH ENDPOINT	Hazard Index
HFC	WB	Central nervous system	13
		Immune system	14
		Reproduction/ development	13
		Hyperpigmentation/keratos is	1.9
		Total HI	30
		Liver	1.7
		Cardiovascular	1.8
		Central nervous system	11
		Immune system	15
		Metabolism	1.7
		Reproduction/ development	11
		Hyperpigmentation/keratos is	1.8
		Total HI	33

NOTE: AFC - average fish consumption      E - eggs  
HFC - high fish consumption      FS - fillet with skin  
HI - hazard index      WB - whole body

- <sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public (adult) of 7.5 g/day, or 1 8-oz meal per month, and for general public (child) of 2.83 g/day, or 0.4 8-oz meal per month (USEPA 2000).
- <sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month, and for general public (child) of 77.95 g/day, or 11 8-oz meals per month (USEPA 2000).
- <sup>c</sup> AFC risk based on average consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month, and for child fish consumers of 24.8 g/day, or 3 8-oz meals per month (CRITFC 1994).
- <sup>d</sup> HFC risk based on 99th percentile consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month, and for child fish consumers of 162 g/day, or 22 8-oz meals per month (CRITFC 1994).

Up to seven health endpoints exceeded a value of 1.0, depending on the target population and exposure parameters used for the calculations. The seven health endpoints were immune system, central nervous system, reproduction/development, cardiovascular, hyperpigmentation/keratosis, liver, and metabolism in decreasing order of toxicity based on hazard indices of whole body samples.

### Chemicals With Hazard Quotients At or Above 1.0.

Individual chemicals with a hazard quotient at or greater than 1.0 in egg, fillet with skin, and whole body samples of coho salmon collected from Site 30 were identified and are shown in Table 1.2. Hazard quotients for other individual chemicals are presented in Appendix G. One chemical was identified with an hazard quotient greater than 1.0 in egg samples of coho salmon, total Aroclors. A total of three individual chemicals with hazard quotients at or above 1.0 were identified in fillet with skin samples of coho salmon: total Aroclors, mercury, and arsenic, in decreasing order of toxicity based on the Native American child, high fish consumption rate. In whole body samples, a total of four individual chemicals were identified at or above 1.0: total Aroclors, mercury, arsenic, and zinc, in decreasing order of toxicity based on the Native American child, high fish consumption rate. Total Aroclors were comprised of Aroclor 1254 in egg samples and Aroclor 1254 and Aroclor 1260 in fillet with skin and whole body samples.

**Table 1.2. Chemicals having hazard quotients at or above 1.0 in coho salmon**

				CHILDREN			
HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)	TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)	
AFC	HFC			AFC	HFC		
General Public							
Eggs							
Total	—	nd	Total	—	nd		
Aroclors				Aroclors			
Fillet with skin							
Total	—	2.6	30 (1)	Total	—	3.3	
Aroclors				Aroclors			
Mercury		2.4	30 (1)	Mercury	—	3.0	
Whole body							
Total	—	2.9	30 (1)	Total	—	3.7	30 (1)
Aroclors				Aroclors			
Mercury	—	2.1	30 (1)	Mercury	—	2.7	30 (1)
Native American							
Eggs							
Total	—	nd		Total	1.2	nd	30 (1)
Aroclors				Aroclors			
Fillet with skin							
Total	1.1	7.0	30 (1)	Total	2.1	14	30 (1)
Aroclors				Aroclors			
Arsenic	—	1.0	30 (1)	Arsenic	—	1.9	30 (1)
Mercury	1.1	6.5	30 (1)	Mercury	1.9	13	30 (1)
Whole body							
Total	1.3	7.8	30 (1)	Total	2.3	15	30 (1)
Aroclors				Aroclors			
Mercury	—	5.8	30 (1)	Arsenic	—	1.8	30 (1)
				Mercury	1.7	11	30 (1)

NOTE: AFC - average fish consumption  
HFC - high fish consumption

– - value less than 1.0  
**Bold** indicates site with highest HQ  
nd - not determined

<sup>a</sup> Site -Waterbody: 30 - Umatilla River.

## Cancer Risk Estimates

Cancer risks were estimated for general public and Columbia River Basin Native American adults at both 30- and 70-year exposure durations. Cancer risk estimates for detected carcinogenic chemicals are presented in Appendix I. Total cancer risk estimates are presented in Table 1.3. Sampling sites were not replicated and, therefore, tributary and basin risk were not calculated for coho salmon.

**Table 1.3. Total cancer risk for coho salmon collected at Site 30, Umatilla River**

CONSUMPTION RATE/ EXPOSURE DURATION	TISSUE TYPE	TOTAL EXCESS CANCER RISK
<b>General Public<sup>a,b</sup></b>		
AFC/30-yr	E	7x10 <sup>-6</sup>
	FS	8x10 <sup>-6</sup>
	WB	1x10 <sup>-5</sup>
HFC/30-yr	FS	2x10 <sup>-4</sup>
	WB	2x10 <sup>-4</sup>
AFC/70-yr	E	2x10 <sup>-5</sup>
	FS	2x10 <sup>-5</sup>
	WB	2x10 <sup>-5</sup>
HFC/70-yr	FS	4x10 <sup>-4</sup>
	WB	5x10 <sup>-4</sup>
<b>Native American<sup>c,d</sup></b>		
AFC/30-yr	E	6x10 <sup>-5</sup>
	FS	7x10 <sup>-5</sup>
	WB	9x10 <sup>-5</sup>
HFC/30-yr	FS	4x10 <sup>-4</sup>
	WB	5x10 <sup>-4</sup>
AFC/70-yr	E	1x10 <sup>-4</sup>
	FS	2x10 <sup>-4</sup>
	WB	2x10 <sup>-4</sup>
HFC/70-yr	FS	1x10 <sup>-3</sup>
	WB	1x10 <sup>-3</sup>

NOTE: AFC - average fish consumption  
HFC - high fish consumption  
E - eggs  
FS - fillet with skin  
WB - whole body



- <sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 7.5 g/day, or 1 8-oz meal per month (USEPA 2000).
- <sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month (USEPA 2000).
- <sup>c</sup> AFC risk based on average consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month (CRITFC 1994).
- <sup>d</sup> HFC risk based on 99th percentile consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month (CRITFC 1994).
- <sup>e</sup> Site - Waterbody: 30 - Umatilla River.

### **Carcinogenic Chemicals with Estimated Cancer Risks At or Above $10^{-5}$**

Cancer risk estimates vary across populations, consumption rates, and exposure levels by constant factors. Chemicals in coho salmon fillet with skin or whole body samples with cancer risks at or above  $1 \times 10^{-5}$  are shown for the Columbia River Basin Native American population with average fish consumption rates at a 70-year exposure duration; total cancer risks for all chemicals are also shown (Tables 1.4.1 and 1.4.2). Multiplicative factors used to estimate risk at different exposure parameters and target populations are footnoted in the table. In addition, Appendix I shows individual risk estimates for each detected chemical for all the exposure scenarios used in this risk assessment.

A total of four chemicals were identified as having cancer risks at or above  $1 \times 10^{-5}$  for coho salmon: arsenic, adjusted Aroclors, PCB 126, and PCB 118. **Arsenic had the highest risk estimate for all tissue types. Adjusted Aroclors had the second highest risk estimate for all tissue types. The individual Aroclors detected and used in the adjusted Aroclor calculation were Aroclor 1254 for egg samples, and Aroclors 1260 and 1254 for fillet with skin and whole body samples.** PCB 126 had the third highest risk estimate for fillet with skin and whole body samples, but was not detected in eggs. PCB 118 had the third highest risk estimate for egg samples.

**Table 1.4.1. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in coho salmon, whole body. Collected at Site 30, Umatilla River**

Coho Salmon - Whole Body		
Chemical		Site
		30
PCBs	Adjusted Aroclors	5E-05
	PCB 126	5E-05
Dioxin/furans	DDE	1E-05
Inorganic	Arsenic	7E-05
Total Cancer Risk for All Chemicals		2E-04

**Table 1.4.2. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in coho salmon, fillet with skin. Collected at Site 30, Umatilla River**

Coho Salmon - Fillet w-skin		
Chemical		Site
		30
PCBs	Adjusted Aroclors	4E-05
	PCB 126	1E-05
Inorganic	Arsenic	7E-05
Total Cancer Risk for All Chemicals		2E-04

NOTE: A blank indicates that this chemical does not have a cancer risk at or above  $1 \times 10^{-5}$  for this tissue type at this site

*To estimate risk levels for general public AFC 30-year exposure, divide the cells in this table by 19.64.*

*To estimate risk levels for general public HFC 30-year exposure, divide the cells in this table by 1.03.*

*To estimate risk levels for Native American AFC 30-year exposure, divide the cells in this table by 2.34.*

*To estimate risk levels for Native American HFC 30-year exposure, divide the cells in this table by 0.38.*

*To estimate risk levels for general public AFC 70-year exposure, divide the cells in this table by 8.43.*

*To estimate risk levels for general public HFC 70-year exposure, divide the cells in this table by 0.44.*  
*To estimate risk levels for Native American AFC 70-year exposure, divide the cells in this table by 0.16.*

## Appendix P-2 Fall Chinook Salmon

Fall chinook salmon were collected from five sites in the Columbia River Basin: 8 and 14, Columbia River; 30, Umatilla River; 48, Yakima River; and 56, Klickitat River. Chemical analyses were performed on egg, fillet with skin, and whole body tissue types. The risk estimates characterized in this section are based on average chemical concentrations determined from 3 replicate composite samples collected from each site except for egg samples at Site 8 which had 1 composite sample and fillet with skin samples at Site 8 and Site 14, which each had 4 replicate composites (Appendix A). Data are presented in two spatial scales: site and basin. Fall chinook salmon were not collected from replicate sampling sites within a tributary and, therefore, tributary risk estimates were not calculated.

### Noncarcinogenic Health Effects

The potential noncarcinogenic health effects associated with the consumption of egg, fillet with skin, and whole body fall chinook salmon were assessed by calculating hazard quotients for all detected chemicals with oral reference doses (Appendix G). The hazard quotients of chemicals with the same health endpoint were summed to calculate endpoint-specific hazard indices. In addition, the hazard quotients of all detected chemicals were summed to calculate a total hazard index for the site or basin. Table 2.1 shows the total hazard index for each of the target populations evaluated in this risk assessment and the health endpoints which were at or above a hazard index of 1.0.

**Table 2.1. Total hazard indices and noncarcinogenic health endpoints with hazard indices at or above 1.0 for fall chinook salmon**

CONSUMPTION RATE/ TISSUE TYPE			HAZARD INDEX					BASIN AVERAGE
			SITE <sup>e</sup>					
			8	14	56	30	48	
HEALTH ENDPOINT								
General Public - Adult <sup>a,b</sup>								
AFC	E	Total HI	0.2	na	na	na	na	0.2
AFC	FS	Total HI	0.2	0.3	0.1	0.2	0.2	0.2
AFC	WB	Total HI	0.2	0.3	0.2	0.3	0.3	0.3
HFC	FS	Central nervous system	1.7	2.3	1.2	1.6	1.7	1.7
		Immune system	1.8	2.9	–	1.2	1.5	1.8
		Reproduction/development	1.7	2.3	1.2	1.6	1.7	1.7
		Total HI	4.5	6.0	2.3	3.5	4.3	4.4
HFC	WB	Central nervous system	1.7	2.0	–	1.5	1.9	1.6
		Immune system	1.6	2.6	1.5	2.6	1.9	2.0
		Reproduction/development	1.7	2.0	–	1.5	1.9	1.6

CONSUMPTION RATE/ TISSUE TYPE			HAZARD INDEX					BASIN AVERAGE
			SITE <sup>e</sup>					
			8	14	56	30	48	
Total HI			4.7	6.1	3.6	5.4	5.1	5.0
General Public - Child <sup>a,b</sup>								
AFC	E	Total HI	0.1	na	na	na	na	0.1
AFC	FS	Total HI	0.2	0.3	0.1	0.2	0.2	0.2
AFC	WB	Total HI	0.2	0.3	0.2	0.2	0.2	0.2
		Total HI	3.9	na	na	na	na	3.9
HFC	FS	Central nervous system	2.2	2.9	1.5	2.1	2.2	2.2
		Immune system	2.3	3.7	–	1.6	1.9	2.3
		Reproduction/development	2.2	2.9	1.5	2.1	2.2	2.2
		Total HI	5.7	7.7	3.0	4.5	5.5	5.6
HFC	WB	Central nervous system	2.2	2.5	1.0	1.9	2.4	2.0
		Immune system	2.0	3.3	1.9	3.4	2.4	2.6
		Reproduction/development	2.2	2.5	1.0	1.9	2.4	2.0
		Total HI	6.0	7.8	4.7	6.9	6.5	6.4
Native American - Adult <sup>c,d</sup>								
AFC	E	Total HI	1.3	na	na	na	na	1.3
AFC	FS	Central nervous system	–	1.0	–	–	–	0.8
		Immune system	–	1.3	–	–	–	0.8
		Reproduction/development	–	1.0	–	–	–	0.8
		Total HI	2.0	2.7	1.0	1.6	1.9	2.0
AFC	WB	Immune system	–	1.2	–	1.2	–	0.9
		Total HI	2.1	2.7	1.6	2.4	2.3	2.2
HFC	FS	Cardiovascular	1.8	1.4	1.7	1.0	1.5	1.5
		Central nervous system	4.7	6.2	3.2	4.4	4.7	4.6
		Immune system	4.8	8.0	–	3.4	4.1	4.8
		Reproduction/development	4.7	6.2	3.2	4.4	4.7	4.6
		Hyperpigmentation/keratosis	1.8	1.4	1.7	1.0	1.5	1.5
		Total HI	12	16	6.4	9.6	12	12
HFC	WB	Liver	–	–	–	–	1.0	0.9
		Cardiovascular	1.6	1.7	1.8	1.3	1.5	1.6
		Central nervous system	4.6	5.4	2.2	4.1	5.1	4.3
		Immune system	4.4	7.1	4.1	7.2	5.2	5.6
		Reproduction/development	4.6	5.4	2.1	4.1	5.1	4.3
		Hyperpigmentation/keratosis	1.6	1.7	1.8	1.3	1.5	1.6
		Total HI	13	17	10	15	14	14
Native American - Child <sup>c,d</sup>								
AFC	E	Total HI	2.5	na	na	na	na	2.5
AFC	FS	Central nervous system	1.4	1.8	–	1.3	1.4	1.4
		Immune system	1.4	2.4	–	1.0	1.2	1.4
		Reproduction/development	1.4	1.8	–	1.3	1.4	1.4
		Total HI	3.6	4.9	1.9	2.9	3.5	3.6
AFC	WB	Central nervous system	1.4	1.6	–	1.2	1.5	1.3
		Immune system	1.3	2.1	1.2	2.1	1.5	1.7
		Reproduction/development	1.4	1.6	–	1.2	1.5	1.3

CONSUMPTION RATE/ TISSUE TYPE			HAZARD INDEX					BASIN AVERAGE
			SITE <sup>o</sup>					
			8	14	56	30	48	
HEALTH ENDPOINT			8	14	56	30	48	
HFC	FS	Total HI	3.8	4.9	3.0	4.4	4.1	4.1
		Liver	1.2	1.1	1.2	–	1.6	1.2
		Cardiovascular	3.6	2.7	3.3	2.0	2.9	2.9
		Central nervous system	9.1	12	6.3	8.6	9.2	9.0
		Immune system	9.4	15	1.2	6.6	8.0	9.4
		Reproduction/development	9.1	12	6.3	8.6	9.2	9.0
		Hyperpigmentation/keratosis	3.6	2.7	3.3	2.0	2.9	2.9
		Total HI	24	32	12	19	23	23
HFC	WB	Liver	1.4	1.3	1.4	1.9	2.0	1.7
		Cardiovascular	3.1	3.3	3.4	2.6	3.0	3.1
		Central nervous system	9.0	10	4.2	8.0	9.9	8.3
		Immune system	8.5	14	7.9	14	10	11
		Metabolism	1.2	1.0	1.1	1.1	–	1.0
		Reproduction/development	9.0	10	4.2	8.0	9.9	8.3
		Hyperpigmentation/keratosis	3.1	3.3	3.4	2.6	3.0	3.1
		Selenosis	1.1	–	1.1	1.0	1.0	1.0
Total HI		25	32	19	28	27	27	

NOTE: AFC - average fish consumption      na - not applicable; sample type not      E - eggs  
HFC - high fish consumption      analyzed at this site      FS - fillet with skin  
HI - hazard index      – - health endpoint <1.0 at that site      WB - whole body

<sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public (adult) of 7.5 g/day, or 1 8-oz meal per month, and for general public (child) of 2.83 g/day, or 0.4 8-oz meal per month (USEPA 2000).

<sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month, and for general public (child) of 77.95 g/day, or 11 8-oz meals per month (USEPA 2000).

<sup>c</sup> AFC risk based on average consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month, and for child fish consumers of 24.8 g/day, or 3 8-oz meals per month (CRITFC 1994).

<sup>d</sup> HFC risk based on 99th percentile consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month, and for child fish consumers of 162 g/day, or 22 8-oz meals per month (CRITFC 1994).

<sup>e</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam, 14 - located in the upper Columbia River above the Snake River; 30 - Umatilla River; 48 - Yakima River; 56 - Klickitat River.

Up to eight health endpoints had hazard indices at or above 1.0, depending on the target population and exposure parameters used for calculation. The eight health endpoints were immune system, central nervous system, reproduction/development, cardiovascular, hyperpigmentation/keratosis, liver, selenosis, and metabolism, in decreasing order of toxicity based on basin average hazard indices of whole body samples. Among specific sampling sites,

total hazard indices for both fillet with skin and whole body samples were lowest at Site 56 in the Klickitat River and were generally two to three times higher at Site 14 in the Columbia River. Total hazard indices among sample sites varied by a factor of 2.6 in fillet with skin samples and by 1.7 in whole body samples.

### Chemicals With Hazard Quotients At or Above 1.0

The individual chemicals with a hazard quotient at or above 1.0 in fillet with skin and whole body fall chinook samples from five sites are identified in Table 2.2. No hazard quotients were above 1.0 for eggs. The hazard quotients for all individual chemicals are presented in Appendix G. A total of three individual chemicals were identified with hazard quotients at or above 1.0 in fillet with skin samples of fall chinook salmon: total Aroclors, mercury, and arsenic, in decreasing order of toxicity based on the Native American child, high fish consumption rate. A total of six individual chemicals were at or above 1.0 in whole body samples of fall chinook salmon: total Aroclors, mercury, arsenic, copper, selenium, and zinc, in decreasing order of toxicity based on the Native American child, high fish consumption rate. Total Aroclors were comprised of Aroclor 1254 in fillet with skin and whole body samples.

**Table 2.2. Chemicals having hazard quotients at or above 1.0 in fall chinook salmon**

ADULTS				CHILDREN			
TISSUE TYPE/CHEMICALS	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (TOTAL # OF SITES)	TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)
	AFC	HFC			AFC	HFC	
<b>General Public</b>							
Eggs	-	nd			-	nd	
Fillet with skin							
Total	—	1.2-2.9	8, <b>14</b> ,30,48 (5)	Total	—	1.6-3.7	8, <b>14</b> ,30,48 (5)
Aroclors				Aroclors			
Mercury	—	1.2-2.3	8, <b>14</b> ,56, <b>30</b> ,48 (5)	Mercury	—	1.5-2.9	8, <b>14</b> ,56,30,48 (5)
Whole body							
Total	—	1.5-2.6	8, <b>14</b> ,56,30,48 (5)	Total	—	1.9-3.4	8,14,56, <b>30</b> ,48 (5)
Aroclors				Aroclors			
Mercury	—	1.5-2.0	8, <b>14</b> ,30,48 (5)	Mercury	—	1.0-2.5	8, <b>14</b> ,56,30,48 (5)
<b>Native American</b>							
Eggs	-	nd			-	nd	
Fillet with skin							
Total	1.3	3.4-8.0	8 <sup>b</sup> , <b>14</b> ,30 <sup>b</sup> ,48 <sup>b</sup> (5)	Total	1.0-2.4	1.2-16	8, <b>14</b> ,56 <sup>b</sup> ,30,48 (5)
Aroclors				Aroclors			
Arsenic	—	1.0-1.8	8,14,56,30,48	Arsenic	—	2.0-3.6	8,14,56,30,48

Mercury	1.0	3.2-6.2	(5) 8, <b>14</b> ,56,30,48 (5)	Mercury	1.3-1.8	6.3-12	(5) 8, <b>14</b> ,56 <sup>b</sup> ,30,4 8 (5)
<b>Whole body</b>							
Total	1.2	4.1-7.1	8 <sup>b</sup> , <b>14</b> ,56 <sup>b</sup> ,30,48 <sup>b</sup> (5)	Total	1.2-2.2	7.9-14	8, <b>14</b> ,56, <b>30</b> ,48 (5)
Aroclors				Aroclors			
Arsenic	–	1.3-1.8	8,14, <b>56</b> ,30,48 (5)	Arsenic	–	2.6-3.4	8, <b>14</b> , <b>56</b> ,30,48 (5)
Mercury	–	2.1-5.4	8, <b>14</b> ,56,30,48 (5)	Copper	–	1.7-1.8	8, <b>14</b> (5)
				Mercury	1.2-1.6	4.2-10	8, <b>14</b> ,56,30,48 (5)
				Selenium	–	1.0-1.1	<b>8</b> , <b>56</b> ,30,48 (5)
				Zinc	–	1.0-1.1	<b>8</b> ,30 (5)

NOTE: AFC - average fish consumption  
HFC - high fish consumption

– - value less than 1.0

**Bold** indicates site with highest HQ

nd-not determined

<sup>a</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam, 14 - located in the upper Columbia River above the Snake River; 30 - Umatilla River; 48 - Yakima River; 56 - Klickitat River.

<sup>b</sup> HFC only

## Cancer Risk Estimates

Cancer risks were estimated for general public and Columbia River Basin Native American adults at both 30- and 70-year exposure durations. Cancer risk estimates for detected carcinogenic chemicals at each sampling site are presented in Appendix I. Total cancer risk estimates are presented in Table 2.3 for each sampling site and for the basin average. Sampling sites were not replicated within a tributary and, therefore, tributary risk estimates were not calculated for fall chinook salmon.

**Table 2.3 Total cancer risks for fall chinook salmon**

CONSUMPTION RATE/ EXPOSURE DURATION	TISSUE TYPE	TOTAL EXCESS CANCER RISK					BASIN AVERAGE
		SITE <sup>9</sup>					
		8	14	56	30	48	
General Public <sup>a,b</sup>							
AFC/30-yr	E	4x10 <sup>-6</sup>	na	na	na	na	4x10 <sup>-6</sup>
	FS	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	9x10 <sup>-6</sup>	7x10 <sup>-6</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>
	WB	9x10 <sup>-6</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>
HFC/30-yr	FS	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	1x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	WB	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
AFC/70-yr	E	9x10 <sup>-6</sup>	na	na	na	na	9x10 <sup>-6</sup>
	FS	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	2x10 <sup>-5</sup>	2x10 <sup>-5</sup>	2x10 <sup>-5</sup>	2x10 <sup>-5</sup>
	WB	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>
HFC/70-yr	FS	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	4x10 <sup>-4</sup>	3x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>



<b>Native American<sup>c,d</sup></b>	WB	4x10 <sup>-4</sup>	6x10 <sup>-4</sup>	4x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>
	E	3x10 <sup>-5</sup>	na	na	na	na	3x10 <sup>-5</sup>
AFC/30-yr	FS	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	8x10 <sup>-5</sup>	6x10 <sup>-5</sup>	9x10 <sup>-5</sup>	9x10 <sup>-5</sup>
	WB	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>
HFC/30-yr	FS	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	5x10 <sup>-4</sup>	4x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>
	WB	5x10 <sup>-4</sup>	7x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>
AFC/70-yr	E	8x10 <sup>-5</sup>	na	na	na	na	8x10 <sup>-5</sup>
	FS	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	1x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
HFC/70-yr	WB	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	FS	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	9x10 <sup>-4</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>
	WB	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>

NOTE: AFC - average fish consumption

E - eggs

HFC - high fish consumption

FS - fillet with skin

na - not applicable; sample type not analyzed at this site

WB - whole body

<sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 7.5 g/day, or 1 8-oz meal per month (USEPA 2000).

<sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month (USEPA 2000).

<sup>c</sup> AFC risk based on average consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month (CRITFC 1994).

<sup>d</sup> HFC risk based on 99th percentile consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month (CRITFC 1994).

<sup>e</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam, 14 - located in the upper Columbia River above the Snake River; 30 - Umatilla River ; 48 - Yakima River; 56 - Klickitat River.

## Chemicals with Estimated Cancer Risks At or Above $1 \times 10^{-5}$

Cancer risk estimates vary across populations, consumption rates, and exposure levels by constant factors. Chemicals in fall chinook salmon fillet with skin or whole body samples with cancer risks at or above  $1 \times 10^{-5}$  are shown for the Columbia River Basin Native American population with average fish consumption rates at a 70-year exposure duration; total cancer risks for all chemicals are also shown (Tables 2.4.1 and 2.4.2). Multiplicative factors used to estimate risk at different exposure parameters and target populations are footnoted in the table. In addition, Appendix I shows individual risk estimates for each detected chemical for all the exposure scenarios used in this risk assessment.

A total of five chemicals were found at risk levels at or above  $1 \times 10^{-5}$  for fall chinook salmon, depending on sampling site: arsenic, adjusted Aroclors, PCB 126, PCB 118, and 2,3,7,8-TCDF. Arsenic had the highest risk estimate for all sites and tissue types. Adjusted Aroclors had the

second or third highest risk estimate for all sites and tissue types. Aroclor 1254 was the only individual Aroclor detected and used in the adjusted Aroclor calculation.

**Table 2.4.1 Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in fall chinook salmon, whole body**

		Fall Chinook - Whole Body				
		Site				
	Chemical	8	14	30	48	56
PCBs	Adjusted Aroclors	3E-05	4E-05	4E-05	3E-05	3E-05
	PCB 118		2E-05	1E-05		
	PCB 126	1E-05	4E-05	3E-05	2E-05	
Dioxin/furans	2,3,7,8-TCDF		1E-05	1E-05	1E-05	
Inorganic	Arsenic	1E-04	1E-04	1E-04	1E-04	1E-04
Total Cancer Risk for All Chemicals		2E-04	3E-04	2E-04	2E-04	2E-04

**Table 2.4.2 Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in fall chinook salmon, fillet with skin**

		Fall Chinook - Fillet w-skin				
		Site				
	Chemical	8	14	30	48	56
PCBs	Adjusted Aroclors	3E-05	5E-05	2E-05	3E-05	2E-05
	PCB 118		1E-05			
	PCB 126	2E-05	3E-05	1E-05	3E-05	
Dioxin/furans	2,3,7,8-TCDF	1E-05	1E-05			
Inorganic	Arsenic	1E-04	1E-04	8E-05	1E-04	1E-04
Total Cancer Risk for All Chemicals		2E-04	2E-04	1E-04	2E-04	2E-04

NOTE: A blank indicates that this chemical does not have a cancer risk at or above  $1 \times 10^{-5}$  for this tissue type at this site

To estimate risk levels for general public AFC 30-year exposure, divide the cells in this table by 19.64.

To estimate risk levels for general public HFC 30-year exposure, divide the cells in this table by 1.03.

To estimate risk levels for Native American AFC 30-year exposure, divide the cells in this table by 2.34.

To estimate risk levels for Native American HFC 30-year exposure, divide the cells in this table by 0.38.

To estimate risk levels for general public AFC 70-year exposure, divide the cells in this table by 8.43.

To estimate risk levels for general public HFC 70-year exposure, divide the cells in this table by 0.44.

To estimate risk levels for Native American AFC 70-year exposure, divide the cells in this table by 0.16.

<sup>a</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam, 14 - located in the upper Columbia River above the Snake River; 30 - Umatilla River ; 48 - Yakima River; 56 - Klickitat River.

### Appendix P-3 Spring Chinook Salmon

Spring chinook salmon were collected from eight sites in the Columbia River Basin: 21, Willamette River; 30, Umatilla River; 48, Yakima River; 51, Wenatchee River; 56, Klickitat River; 62, Little White Salmon River; 63, Wind River; and 94, Grande Rhonde River. Chemical analyses were performed on egg, fillet with skin, and whole body tissue types. The risk estimates characterized in this section are based on average chemical concentrations determined from 3 replicate composite samples collected from each site (Appendix A). Data are presented at two spatial scales: site and basin. Spring chinook salmon were not collected from replicate sampling sites within a tributary and, therefore, tributary risk estimates were not calculated.

#### Noncarcinogenic Health Effects

The potential noncarcinogenic health effects associated with the consumption of egg, fillet with skin, and whole body spring chinook salmon were assessed by calculating hazard quotients for all detected chemicals with oral reference doses (Appendix G). The hazard quotients of chemicals with the same health endpoint were summed to calculate endpoint-specific hazard indices. In addition, the hazard quotients of all detected chemicals were summed to calculate a total hazard index for the site or basin. Table 3.1 shows the total hazard index for each of the target populations evaluated in this risk assessment and the health endpoints at or above a hazard index of 1.0.

**Table 3.1. Total hazard indices and noncarcinogenic health endpoints with hazard indices at or above 1.0 for spring chinook salmon**

CONSUMPTION			HAZARD INDEX								
			SITE <sup>o</sup>							BASIN	
			RATE/ TISSUE TYPE	HEALTH ENDPOINT	21	63	62	56	94		30
General Public - Adult <sup>a,b</sup>											
AFC	E	Total HI	na	na	na	na	0.24	0.25	na	na	0.25
AFC	FS	Total HI	0.11	0.22	0.16	0.47	0.22	0.24	0.14	0.25	0.25
AFC	WB	Total HI	0.17	0.18	0.19	0.28	0.25	0.27	0.18	0.18	0.25
HFC	FS	Central nervous system	—	1.7	—	6.2	1.6	1.5	—	2.3	2.1
		Immune system	1.0	1.5	1.8	1.7	1.7	2.2	1.7	1.6	1.6
		Reproduction/development	—	1.7	—	6.2	1.6	1.5	—	2.3	2.1
		Total HI	2.2	4.3	3.0	8.9	4.2	4.6	2.7	4.8	4.8
HFC	WB	Central nervous system	—	—	—	1.9	1.6	1.6	—	—	1.3
		Immune system	1.6	2.0	1.8	2.0	1.7	2.0	1.8	1.8	1.8
		Reproduction/development	—	—	—	1.9	1.6	1.6	—	—	1.3
		Total HI	3.3	3.4	3.6	5.4	4.7	5.1	3.3	3.4	4.7
General Public - Child <sup>a,b</sup>											
AFC	E	Total HI	na	na	na	na	0.21	0.22	na	na	0.22
AFC	FS	Total HI	0.10	0.20	0.14	0.41	0.20	0.21	0.12	0.22	0.22

CONSUMPTION			HAZARD INDEX									
RATE/ TISSUE TYPE		HEALTH ENDPOINT	SITE <sup>e</sup>								BASIN AVERAGE	
			21	63	62	56	94	30	48	51		
AFC	WB	Total HI	0.15	0.16	0.17	0.25	0.22	0.24	0.16	0.16	0.22	
HFC	FS	Central nervous system	–	2.1	–	8.0	2.1	1.9	–	2.9	2.6	
		Immune system	1.3	1.9	2.3	2.1	2.1	2.8	2.2	2.0	2.1	
		Reproduction/development	–	2.1	–	8.0	2.1	1.9	–	2.9	2.6	
		Total HI	2.8	5.5	3.8	11	5.4	5.9	3.4	6.1	6.1	
HFC	WB	Central nervous system	–	–	–	2.5	2.0	2.1	–	–	1.7	
		Immune system	2.0	2.5	2.3	2.5	2.1	2.6	2.3	2.3	2.4	
		Reproduction/development	–	–	–	2.5	2.0	2.1	–	–	1.7	
		Total HI	4.2	4.3	4.6	6.9	6.0	6.5	4.3	4.4	6.1	
Native American - Adult <sup>c,d</sup>												
AFC	E	Total HI	na	na	na	na	2.0	2.1	na	na	2.1	
		Central nervous system	–	–	–	2.8	–	–	–	1.0	0.92	
		Reproduction/development	–	–	–	2.8	–	–	–	1.0	0.92	
		Total HI	1.0	1.9	1.3	4.0	1.9	2.1	1.2	2.1	2.1	
HFC	WB	Total HI	1.5	1.5	1.6	2.4	2.1	2.3	1.5	1.5	2.1	
	FS	Cardiovascular	1.6	1.7	1.7	1.5	1.5	1.5	1.5	1.6	1.6	
		Central nervous system	–	4.5	–	17	4.5	4.1	–	6.3	5.7	
		Immune system	2.8	4.0	4.8	4.5	4.5	6.0	4.7	4.3	4.5	
		Reproduction/development	–	4.5	–	17	4.5	4.1	–	6.3	5.6	
		Hyperpigmentation/keratosis	1.6	1.7	1.7	1.5	1.5	1.5	1.5	1.6	1.6	
		Total HI	5.9	12	8.1	24	11	13	7.3	13	13	
	WB	Liver	–	–	–	1.0	–	–	1.0	1.0	0.94	
		Cardiovascular	1.9	1.5	1.6	1.1	1.6	1.5	1.6	1.6	1.5	
		Central nervous system	–	–	–	5.3	4.3	4.4	–	–	3.6	
		Immune system	4.4	5.4	4.9	5.4	4.5	5.5	4.9	4.9	5.0	
Reproduction/development		–	–	–	5.3	4.3	4.4	–	–	3.6		
Hyperpigmentation/keratosis		1.9	1.5	1.6	1.1	1.6	1.5	1.6	1.6	1.5		
Total HI	9.1	9.3	9.9	15	13	14	9.1	9.3	13			
Native American - Child <sup>c,d</sup>												
AFC	E	Liver	na	na	na	na	1.5	1.5	na	na	1.5	
		Immune system	na	na	na	na	1.4	1.5	na	na	1.4	
		Selenosis	na	na	na	na	1.4	1.4	na	na	1.4	
		Total HI	na	na	na	na	3.6	3.9	na	na	3.8	
	FS	Central nervous system	–	1.3	–	5.1	1.3	1.2	–	1.9	1.7	
		Immune system	–	1.2	1.4	1.4	1.4	1.8	1.4	1.3	1.3	
		Reproduction/development	–	1.3	–	5.1	1.3	1.2	–	1.9	1.7	
		Total HI	1.8	3.5	2.4	7.3	3.4	3.8	2.2	3.9	3.9	
	WB	Central nervous system	–	–	–	1.6	1.3	1.3	–	–	1.1	
		Immune system	1.3	1.6	1.5	1.6	1.4	1.6	1.5	1.5	1.5	
		Reproduction/development	–	–	–	1.6	1.3	1.3	–	–	1.1	
		Total HI	2.7	2.8	2.9	4.4	3.8	4.2	2.7	2.8	3.9	
	HFC	FS	Liver	1.1	1.2	1.3	1.1	1.2	1.3	1.5	1.2	1.3
			Cardiovascular	3.1	3.2	3.4	2.9	3.0	2.9	2.9	3.1	3.1
			Central nervous system	–	8.8	–	33	8.7	8.0	–	12	11
			Immune system	5.4	7.7	9.4	8.8	8.8	12	9.2	8.3	8.7
			Reproduction/development	–	8.8	–	33	8.7	8.0	–	12	11
			Hyperpigmentation/keratosis	3.1	3.2	3.4	2.9	3.0	2.9	2.9	3.1	3.1
			Gastrointestinal	1.4	1.2	1.2	–	–	–	–	–	0.6
			Total HI	11	23	16	47	22	25	14	25	25
WB		Liver	1.5	1.8	1.8	1.9	1.5	1.7	2.0	2.0	1.8	
		Kidney	–	1.4	1.5	1.1	1.5	1.5	1.4	1.4	1.3	
		Cardiovascular	3.6	2.8	3.1	2.1	3.1	3.0	3.2	3.2	3.0	
		Central nervous system	–	–	–	10	8.3	8.6	–	–	7.0	

CONSUMPTION		HAZARD INDEX								
RATE/ TISSUE TYPE	HEALTH ENDPOINT	SITE <sup>o</sup>								BASIN AVERAGE
		21	63	62	56	94	30	48	51	
	Immune system	8.5	10	9.5	10	8.8	11	9.5	9.5	9.8
	Metabolism	1.7	—	1.0	1.4	—	—	—	—	1.1
	Reproduction/development	—	—	—	10	8.3	8.6	—	—	6.9
	Hyperpigmentation/keratosis	3.6	2.8	3.1	2.1	3.1	3.0	3.2	3.2	3.0
	Selenosis	—	1.2	1.2	1.2	—	1.2	1.2	1.2	1.1
	Gastrointestinal	1.8	—	1.8	—	—	—	—	—	0.8
	Total HI	18	18	19	29	25	25	18	18	25

NOTE: AFC - average fish consumption      na - not applicable; sample type not analyzed at this site      E - eggs  
HFC - high fish consumption      — - indicates health endpoint <1.0 at that site      FS - fillet with skin  
HI - hazard index      WB - whole body

<sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public (adult) of 7.5 g/day, or 1 8-oz meal per month, and for general public (child) of 2.83 g/day, or 0.4 8-oz meal per month (USEPA 2000).

<sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month, and for general public (child) of 77.95 g/day, or 11 8-oz meals per month (USEPA 2000).

<sup>c</sup> AFC risk based on average consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month, and for child fish consumers of 24.8 g/day, or 3 8-oz meals per month (CRITFC 1994).

<sup>d</sup> HFC risk based on 99th percentile consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month, and for child fish consumers of 162 g/day, or 22 8-oz meals per month (CRITFC 1994).

<sup>e</sup> Site - Waterbody: 21 - Willamette River; 30 - Umatilla River; 48 - Yakima River; 51 - Wenatchee River; 56 - Klickitat River; 62 - Little White Salmon River; 63 - Wind River; 94 - Grande Rhonde River.

A total of ten health endpoints exceeded a hazard index of 1.0 depending on the target population and exposure parameters used for the calculation. The ten health endpoints were immune system, central nervous system, reproduction/development, cardiovascular, hyperpigmentation/keratosis, liver, kidney, metabolism, selenosis, and gastrointestinal in decreasing order of toxicity based on basin average **hazard indices**. Among specific sampling sites, total hazard indices for both fillet with skin and whole body samples were lowest at Site 21 in the Willamette River and 1.6 to three times higher at Site 56 in the Klickitat River.

### Chemicals With Hazard Quotients At or Above 1.0

Individual chemicals with a hazard quotient at or above 1.0 in egg samples of spring chinook salmon and in fillet with skin and whole body samples of spring chinook salmon were identified and are presented in Table 3.2. Hazard quotients for other individual chemicals are presented in Appendix G. A total of two individual chemicals were identified as having hazard quotients at or above 1.0 in egg samples of spring chinook salmon: total Aroclors and selenium. A total of four individual chemicals were identified with hazard quotients above 1.0 in fillet with skin samples of

spring chinook salmon: mercury, total Aroclors, arsenic, and chromium, in decreasing order of toxicity based on the Native American child, high fish consumption rate. A total of seven individual chemicals were identified with hazard quotients above 1.0 in whole body samples of spring chinook salmon: total Aroclors, mercury, arsenic, chromium, cadmium, selenium, and zinc, in decreasing order of toxicity based on the Native American child, high fish consumption rate. Total Aroclors were comprised of Aroclor 1254 in egg, fillet with skin, and whole body samples.

**Table 3.2 Chemicals having hazard quotients at or above 1.0 in spring chinook salmon**

ADULTS				CHILDREN			
TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)	TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)
General Public							
Eggs	-	nd			-	nd	
Fillet with skin							
Total	—	1.0-2.2	21,63,62,56, <b>30</b> ,	Total	—	1.3-2.8	21,63,62,56, <b>30</b> ,94,
Aroclors			94,48,51 (8)	Aroclors			48,51 (8)
Mercury	—	1.5-6.2	63, <b>56</b> ,30,94,51 (8)	Mercury	—	1.9-8.0	63, <b>56</b> ,30,94,51 (8)
Whole body							
Total	—	1.6-2.0	21, <b>63</b> ,62, <b>56</b> , <b>30</b> ,9	Total	—	2.0-2.6	21,63,62,56, <b>30</b> ,94,
Aroclors			4,48,51 (8)	Aroclors			48,51 (8)
Mercury	—	1.6-1.9	<b>56</b> ,30,94 (8)	Mercury	—	2.0-2.5	<b>56</b> ,30,94 (8)
Native American							
Eggs							
Total	—	nd		Total	1.4-1.5	nd	<b>30</b> ,94 (2)
Aroclors				Aroclors			
Selenium	—	nd		Selenium	1.4	nd	<b>30</b> ,94 (2)
Fillet with skin							
Total	—	2.8-6.0	21,63,62,56, <b>30</b> ,	Total	1.2-1.8	5.4-12	21 <sup>b</sup> ,63,62,56, <b>30</b> ,
Aroclors			94,48,51 (8)	Aroclors			94,48,51 (8)
Arsenic	—	1.5-1.7	21, <b>63</b> , <b>62</b> ,56,30,	Arsenic	—	2.9-3.4	21,63, <b>62</b> ,56,30,
			94,48,51 (8)				94,48,51 (8)
Mercury	1.0- 2.8	4.1-17	63 <sup>b</sup> , <b>56</b> ,30 <sup>b</sup> ,94 <sup>b</sup> ,5 1 (8)	Chromium	—	1.2-1.4	<b>21</b> ,63,62 (8)
				Mercury	1.2-5.1	8.0-33	63, <b>56</b> ,30,94,51 (8)
Whole body							
Total Aroclors	—	4.4-5.5	21,63,62,56, <b>30</b> ,	Total Aroclors	1.3-1.6	8.5-11	21,63,62,56, <b>30</b> ,
			94,48,51 (8)				94,48,51 (8)
Arsenic	—	1.1-1.9	<b>21</b> ,63,62,56,30,	Arsenic	—	2.1-3.6	<b>21</b> ,63,62,56,30,94,48,
			94,48,51 (8)				51 (8)
Mercury	—	4.3-5.3	<b>56</b> ,30,94 (8)	Cadmium	—	1.1-1.7	63,62,56,30,94,48, <b>51</b> (8)
				Chromium	—	1.8	<b>21</b> , <b>62</b> (8)
				Mercury	1.3-1.6	8.3-10	<b>56</b> ,30,94 (8)
				Selenium	—	1.1-1.3	63, <b>62</b> ,56,30,48,51 (8)
				Zinc	—	1.1-1.2	<b>21</b> ,56, <b>30</b> (8)

NOTE: AFC - average fish consumption  
HFC - high fish consumption

-- value less than 1.0

**Bold** indicates site with highest HQ

nd-not determined

<sup>a</sup> Site - Waterbody: 21 - Willamette River; 30 - Umatilla River; 48 - Yakima River; 51 - Wenatchee River; 56 - Klickitat River; 62 - Little White Salmon River; 63 - Wind River; 94 - Grande Ronde River.

<sup>b</sup> HFC only

## Cancer Risk Estimates

Cancer risks were estimated for general public and Columbia River Basin Native American adults at both 30- and 70-year exposure durations. Cancer risk estimates for detected carcinogenic chemicals at each sampling site are presented in Appendix I. Total cancer risk estimates are presented in Table 3.3 for each sampling site and for the basin average. Sampling sites were not replicated within a tributary and, therefore, tributary risk estimates were not calculated for spring chinook salmon.

**Table 3.3. Total cancer risks for spring chinook salmon**

CONSUMPTION		TOTAL EXCESS CANCER RISK								
RATE/ EXPOSURE DURATION	TISSUE TYPE	SITE <sup>e</sup>								BASIN AVERAGE
		21	63	62	56	94	30	48	51	
General Public <sup>a,b</sup>										
AFC/30-yr	E	na	na	na	na	9x10 <sup>-6</sup>	9x10 <sup>-6</sup>	na	na	9x10 <sup>-6</sup>
	FS	9x10 <sup>-6</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	9x10 <sup>-6</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>
	WB	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>
HFC/30-yr	FS	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	WB	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
AFC/70-yr	E	na	na	na	na	2x10 <sup>-5</sup>	2x10 <sup>-5</sup>	na	na	2x10 <sup>-5</sup>
	FS	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>
	WB	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>
HFC/70-yr	FS	4x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	4x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>
	WB	6x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>
Native American <sup>c,d</sup>										
AFC/30-yr	E	na	na	na	na	7x10 <sup>-5</sup>	8x10 <sup>-5</sup>	na	na	8x10 <sup>-5</sup>
	FS	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>
	WB	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>
HFC/30-yr	FS	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	7x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	7x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>
	WB	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	7x10 <sup>-4</sup>	7x10 <sup>-4</sup>	7x10 <sup>-4</sup>	7x10 <sup>-4</sup>
AFC/70-yr	E	na	na	na	na	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	na	na	2x10 <sup>-4</sup>



CONSUMPTION RATE/ EXPOSURE DURATION	TISSUE TYPE	TOTAL EXCESS CANCER RISK								
		SITE <sup>e</sup>								BASIN AVERAGE
		21	63	62	56	94	30	48	51	
HFC/70-yr	FS	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	WB	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	FS	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>
	WB	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>	2x10 <sup>-3</sup>	2x10 <sup>-3</sup>	2x10 <sup>-3</sup>

NOTE: AFC - average fish consumption

E - eggs

HFC - high fish consumption

FS - fillet with skin

na - not applicable; sample type not analyzed at this site

WB - whole body

<sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 7.5 g/day, or 1 8-oz meal per month (USEPA 2000).

<sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month (USEPA 2000).

<sup>c</sup> AFC risk based on average consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month (CRITFC 1994).

<sup>d</sup> HFC risk based on 99th percentile consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month (CRITFC 1994).

<sup>e</sup> Site - Waterbody: 21 - Willamette River; 30 - Umatilla River; 48 - Yakima River; 51 - Wenatchee River; 56 - Klickitat River; 62 - Little White Salmon River; 63 - Wind River; 94 - Grande Ronde River.

## Carcinogenic Chemicals with Estimated Cancer Risks At or Above 1 X 10<sup>-5</sup>

Cancer risk estimates vary across populations, consumption rates, and exposure levels by constant factors. Chemicals in spring chinook (fillet with skin and in whole body samples) with cancer risks at or above 1 x 10<sup>-5</sup> are shown for the Columbia River Basin Native American population with average fish consumption rates at a 70-year exposure duration; total cancer risk for all chemicals are also shown (Tables 3.4.1 and 3.4.2). Multiplicative factors used to estimate risk at different exposure parameters and target populations are footnoted in the table. In addition, Appendix I shows individual risk estimates for each detected chemical for all the exposure scenarios used in this risk assessment.

A total of seven chemicals were identified with risks at or above 1 x 10<sup>-5</sup> for spring chinook salmon, depending on sampling site: arsenic, adjusted Aroclors, PCB 126, PCB 118, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDD, and 2,3,4,7,8-PeCDF. Arsenic had the highest risk estimate for all sites and tissue types. Adjusted Aroclors had the second or third highest risk estimate for all sites and tissue types. Aroclor 1254 was the only individual Aroclor detected and used in the adjusted Aroclor calculation.

**Table 3.4.1. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in spring chinook salmon, whole body**

		Spring Chinook - Whole Body							
		Site							
	Chemical	21	30	48	51	56	62	63	94
PCBs	Adjusted Aroclors	3E-05	3E-05	3E-05	3E-05	3E-05	3E-05	3E-05	3E-05
	PCB 118					1E-05			
	PCB 126	3E-05	5E-05	2E-05	3E-05	4E-05	3E-05	4E-05	2E-05
Dioxin/furans	1,2,3,7,8-PeCDD		2E-05	3E-05	1E-05	2E-05			
	2,3,4,7,8-PeCDF			1E-05	1E-05	1E-05		1E-05	1E-05
	2,3,7,8-TCDF	1E-05		1E-05	1E-05	1E-05		1E-05	1E-05
Inorganic	Arsenic	1E-04	1E-04	1E-04	1E-04	8E-05	1E-04	1E-04	1E-04
Total Cancer Risk for All Chemicals		2E-04	3E-04	3E-04	2E-04	2E-04	2E-04	2E-04	2E-04

**Table 3.4.2. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in spring chinook salmon, fillet with skin**

		Spring Chinook - Fillet w-skin							
		Site							
	Chemical	21	30	48	51	56	62	63	94
PCBs	Adjusted Aroclors	2E-05	4E-05	3E-05	3E-05	3E-05	3E-05	2E-05	3E-05
	PCB 126		5E-05	4E-05	4E-05		3E-05	4E-05	3E-05
	PCB 156								
Dioxin/furans	1,2,3,7,8-PeCDD		2E-05		2E-05				1E-05
	2,3,4,7,8-PeCDF			1E-05			1E-05	1E-05	1E-05
	2,3,7,8-TCDF			1E-05					
Inorganic	Arsenic	1E-04	1E-04	1E-04	1E-04	1E-04	1E-04	1E-04	1E-04
Total Cancer Risk for All Chemicals		2E-04	3E-04	2E-04	2E-04	2E-04	2E-04	2E-04	2E-04

NOTE: A blank indicates that this chemical is not at or above a cancer risk of  $1 \times 10^{-6}$  for this tissue type at this site

To estimate risk levels for general population AFC 30-year exposure, divide the cells in this table by 19.64.

To estimate risk levels for general population HFC 30-year exposure, divide the cells in this table by 1.03

To estimate risk levels for Native American AFC 30-year exposure, divide the cells in this table by 2.34

To estimate risk levels for Native American HFC 30-year exposure, divide the cells in this table by 0.38.

To estimate risk levels for general population AFC 70-year exposure, divide the cells in this table by 8.43

To estimate risk levels for general population HFC 70-year exposure, divide the cells in this table by 0.44.

To estimate risk levels for Native American AFC 70-year exposure, divide the cells in this table by 0.16

<sup>a</sup> Site - Waterbody: 21 - Willamette River; 30 - Umatilla River; 48 - Yakima River; 51 - Wenatchee River; 56 - Klickitat River; 62 - Little White Salmon River; 63 - Wind River; 94 - Grande Ronde River.

## Appendix P-4 Steelhead

Steelhead were collected from six sites in the Columbia River Basin: 8, Columbia River; 25, Hood River; 48, Yakima River; 56, Klickitat River; 93, Snake River; and 96, Clearwater River. Chemical analyses were performed on egg, fillet with skin, and whole body tissue types. The risk estimates characterized in this section are based on average chemical concentrations determined from 3 replicate composite samples collected from each site except at Site 8 for egg samples, which had one composite sample, and in fillet with skin and whole body samples, which had 6 replicate composite samples each (Appendix A). Data are presented in two spatial scales: site and basin. Steelhead were not collected from replicate sampling sites within a tributary and, therefore, tributary risk estimates were not calculated.

### Noncarcinogenic Health Effects

The potential noncarcinogenic health effects associated with the consumption of eggs, fillet with skin, and whole body steelhead were assessed by calculating hazard quotients for all detected chemicals with oral reference doses (Appendix G). The hazard quotients of chemicals with the same health endpoint were summed to calculate endpoint-specific hazard indices. In addition, the hazard quotients of all detected chemicals were summed to calculate a total hazard index for the site or basin. Table 4.1 shows the total hazard index for each of the target populations evaluated in this risk assessment and the health endpoints that were at or above a hazard index of 1.0.

**Table 4.1. Total hazard indices and noncarcinogenic health endpoints at or above 1.0 for steelhead**

CONSUMPTION RATE <sup>a/</sup> TISSUE TYPE			HAZARD INDEX						
			SITE <sup>e</sup>						BASIN
			8	25	56	93	96	48	AVERAGE
<b>General Public - Adult<sup>a,b</sup></b>									
AFC	E	Total HI	0.3	na	na	na	na	na	0.3
AFC	FS	Total HI	0.2	0.3	0.2	0.3	0.3	0.3	0.3
AFC	WB	Total HI	0.2	0.3	0.3	0.3	0.4	0.3	0.3
HFC	FS	Central nervous system	1.4	2.8	2.4	2.9	2.6	2.5	2.4
		Immune system	1.2	1.7	1.5	1.7	1.9	2.3	2.5
		Reproduction/ development	1.4	2.8	2.4	2.9	2.6	2.5	2.5
		Total HI	3.3	5.6	4.6	5.1	5.2	5.5	5.8
HFC	WB	Central nervous system	1.0	1.8	1.7	2.0	4.1	1.8	2.1
		Immune system	1.5	1.9	2.0	2.2	2.3	2.8	2.8
		Reproduction/ development	1.0	1.8	1.7	2.0	4.1	1.8	2.1

CONSUMPTION RATE <sup>a/</sup>			HAZARD INDEX						BASIN AVERAGE
			SITE <sup>e</sup>						
			8	25	56	93	96	48	
TISSUE TYPE		HEALTH ENDPOINT							
Total HI			3.5	5.3	5.8	5.5	7.8	5.7	6.4
General Public - Child <sup>a,b</sup>									
AFC	E	Total HI	0.2	na	na	na	na	na	0.2
AFC	FS	Total HI	0.2	0.3	0.2	0.2	0.2	0.3	0.3
AFC	WB	Total HI	0.2	0.2	0.3	0.3	0.4	0.3	0.3
HFC	FS	Central nervous system	1.8	3.6	3.0	3.7	3.3	3.2	3.2
		Immune system	1.6	2.2	1.9	2.1	2.4	2.9	3.2
		Reproduction/ development	1.8	3.6	3.0	3.7	3.3	3.2	3.2
HFC	WB	Total HI	4.2	7.2	5.9	6.5	6.6	7.0	7.3
		Central nervous system	1.3	2.3	2.1	2.5	5.3	2.3	2.7
		Immune system	1.9	2.4	2.5	2.8	2.9	3.6	3.6
		Reproduction/ development	1.3	2.3	2.1	2.5	5.3	2.3	2.7
		Total HI	4.5	6.8	7.4	7.1	10	7.3	8.2
Native American - Adult <sup>c,d</sup>									
AFC	E	Total HI	2.3	na	na	na	na	na	2.3
AFC	FS	Central nervous system	–	1.2	1.0	1.3	1.1	1.1	1.1
		Immune system	–	–	–	–	–	1.0	1.1
		Reproduction/ development	–	1.2	1.0	1.3	1.1	1.1	1.1
		Total HI	1.5	2.5	2.0	2.3	2.3	2.4	2.6
AFC	WB	Central nervous system	–	–	–	–	1.8	–	0.9
		Immune system	–	–	–	–	1.0	1.2	1.3
		Reproduction/ development	–	–	–	–	1.8	–	0.9
		Total HI	1.6	2.4	2.6	2.5	3.5	2.5	2.8
HFC	FS	Cardiovascular	–	1.7	1.2	–	–	–	1.0
		Central nervous system	3.9	7.6	6.4	7.8	7.1	6.8	6.8
		Immune system	3.3	4.8	4.2	4.5	5.1	6.3	6.7
		Reproduction/ development	3.9	7.6	6.4	7.8	7.0	6.8	6.8
		Hyperpigmentation/kerat osis		1.7	1.2	–	–	–	1.0
HFC	WB	Total HI	9.1	15	13	14	14	15	16
		Liver	–	1.2	1.0	1.2	1.1	–	1.1
		Cardiovascular	–	1.7	1.2	–	–	–	1.1
		Central nervous system	2.8	4.9	4.6	5.4	11	4.8	5.8
		Immune system	4.2	5.2	5.4	6.0	6.2	7.7	7.7
		Metabolism	–	–	2.0	–	–	–	0.7
		Reproduction/ development	2.8	4.9	4.6	5.4	11	4.8	5.7
		Hyperpigmentation/kerat osis	–	1.7	1.2	–	–	–	1.1
Native American - Child <sup>c,d</sup>									
AFC	E	Liver	1.5	na	na	na	na	na	1.5

CONSUMPTION RATE <sup>a/</sup>		HEALTH ENDPOINT	HAZARD INDEX					
			SITE <sup>e</sup>					BASIN AVERAGE
			8	25	56	93	96	
TISSUE TYPE								
AFC	FS	Immune system	1.2	na	na	na	na	1.2
		Selenosis	1.5	na	na	na	na	1.5
		Total HI	4.3	na	na	na	na	4.3
		Central nervous system	1.2	2.3	1.9	2.3	2.1	2.0
		Immune system	–	1.4	1.2	1.4	1.5	2.0
		Reproduction/development	1.2	2.3	1.9	2.3	2.1	2.0
	WB	Total HI	2.7	4.6	3.7	4.2	4.2	4.7
		Central nervous system	–	1.5	1.4	1.6	3.4	1.7
		Immune system	1.2	1.6	1.6	1.8	1.8	2.3
		Reproduction/development	–	1.5	1.4	1.6	3.4	1.7
HFC	FS	Total HI	2.8	4.3	4.7	4.5	6.3	5.2
		Liver	–	1.2	1.0	1.1	1.4	1.2
		Cardiovascular	1.7	3.3	2.4	1.3	1.6	2.0
		Central nervous system	7.6	15	13	15	14	13
		Immune system	6.5	9.3	8.1	8.8	10	13
		Reproduction/development	7.6	15	12	15	14	13
	WB	Hyperpigmentation/keratosis	1.7	3.3	2.4	1.3	1.6	2.0
		Total HI	18	30	24	27	27	31
		Liver	1.4	2.3	2.0	2.3	2.1	2.1
		Cardiovascular	1.7	3.2	2.4	1.6	1.9	2.1
HFC	FS	Central nervous system	5.4	9.5	8.9	11	22	11
		Immune system	8.1	10	10	12	12	15
		Metabolism	–	–	4.0	–	–	1.3
		Reproduction/development	5.4	9.5	8.9	11	22	11
	WB	Hyperpigmentation/keratosis	1.7	3.2	2.4	1.6	1.9	2.1
		Selenosis	1.0	1.9	1.6	1.1	1.3	1.4
		Total HI	19	28	31	29	41	34

NOTE: AFC - average fish consumption      na - not applicable; sample type not analyzed at this site      E - eggs  
HFC - high fish consumption      – - health endpoint <1.0 at that site      FS - fillet with skin  
HI - hazard index      WB - whole body

- <sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public (adult) of 7.5 g/day, or 1 8-oz meal per month, and for general public (child) of 2.83 g/day, or 0.4 8-oz meal per month (USEPA 2000).
- <sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month, and for general public (child) of 77.95 g/day, or 11 8-oz meals per month (USEPA 2000).

- <sup>c</sup> AFC risk based on average consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month, and for child fish consumers of 24.8 g/day, or 3 8-oz meals per month (CRITFC 1994).
- <sup>d</sup> HFC risk based on 99th percentile consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month, and for child fish consumers of 162 g/day, or 22 8-oz meals per month (CRITFC 1994).
- <sup>e</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam; 25 - Hood River; 48 - Yakima River; 56 - Klickitat River; 93 - Snake River; 96 - Clearwater River.

Up to eight health endpoints exceeded a value of 1.0, depending on the target population and exposure parameters used for calculation. The eight health endpoints were immune system, central nervous system, reproduction/development, liver, cardiovascular, hyperpigmentation/keratosis, selenosis, and metabolism, in decreasing order of toxicity based on basin average hazard indices of whole body samples. Among specific sampling sites, total hazard indices for both fillet with skin and whole body samples were lowest at Site 8 in the Columbia River and were generally two times higher in fillet with skin samples at Site 25 and in whole body samples at Site 96. Total hazard index risk estimates among sample sites varied by a factor of 1.7 in fillet with skin samples and 2.2 in whole body samples (Table 6-47).

### **Chemicals With Hazard Quotients At or Above 1.0**

Individual chemicals with a hazard quotient at or above 1.0 in egg samples of steelhead in fillet with skin and whole body samples of steelhead were identified and are presented in Table 4.2. Hazard quotients for other individual chemicals are presented in Appendix G. A total of two individual chemicals had hazard quotients above 1.0 in egg samples of steelhead, selenium and total Aroclors, based on the Native American child, average fish consumption rate. A total of three individual chemicals had hazard quotients greater than 1.0 in fillet with skin samples of steelhead: mercury, total Aroclors, and arsenic, in decreasing order of toxicity based on the Native American child, high fish consumption rate. A total of seven individual chemicals were identified with hazard quotients above 1.0 in whole body samples of steelhead: mercury, total Aroclors, arsenic, nickel, selenium, copper, and total DDT, in decreasing order of toxicity based on the Native American child, high fish consumption rate. Total Aroclors were comprised of Aroclor 1254 in egg samples and Aroclor 1254 and 1260 in fillet with skin and whole body samples.

**Table 4.2. Chemicals having hazard quotients at or above 1.0 in steelhead**



ADULTS				CHILDREN			
TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)	TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)
	AFC	HFC			AFC	HFC	
<b>General Public</b>							
Eggs	-	nd			-	nd	
Fillet with skin							
Total	—	1.2-2.3	8,25,56,93,96, <b>48</b> (6)	Total	—	1.6-2.9	8,25,56,93,96, <b>48</b> (6)
Aroclors				Aroclors			
Mercury	—	1.4-2.9	8,25,56, <b>93</b> ,96,48 (6)	Mercury	—	1.8-3.7	8,25,56, <b>93</b> ,96,48 (6)
Whole body							
Total	—	1.5-2.8	8,25,56,93,96, <b>48</b> (6)	Total	—	1.9-3.6	8,25,56,93,96, <b>48</b> (6)
Aroclors				Aroclors			
Mercury	—	1.0-4.1	8,25,56,93, <b>96</b> ,48 (6)	Mercury	—	1.3-5.3	8,25,56,93, <b>96</b> ,48 (6)
<b>Native American</b>							
Eggs							
Total	—	nd	8 (1)	Total	1.2	nd	8 (1)
Aroclors				Aroclors			
Selenium	—	nd	8 (1)	Selenium	1.5	nd	8 (1)
Fillet with skin							
Total	1.0	3.3-6.3	8 <sup>b</sup> ,25 <sup>b</sup> ,56 <sup>b</sup> ,93 <sup>b</sup> ,96 <sup>b</sup> , <b>48</b> (6)	Total	1.2-1.9	6.5-12	8 <sup>b</sup> ,25,56,93,96, <b>48</b> (6)
Aroclors				Aroclors			
Arsenic	—	1.2-1.7	<b>25</b> ,56 (6)	Arsenic	—	1.3-3.4	8, <b>25</b> ,56,93,96,48 (6)
Mercury	1.0-1.3	3.9-7.8	8 <sup>b</sup> , 25,56, <b>93</b> ,96,48 (6)	Mercury	1.2-2.3	7.6-15	8, <b>25</b> ,56, <b>93</b> ,96,48 (6)
Whole body							
Total Aroclors	1.0-1.2	4.2-7.7	8 <sup>b</sup> ,25 <sup>b</sup> ,56 <sup>b</sup> ,93,96, <b>48</b> (6)	Total Aroclors	1.2-2.3	8.1-15	8,25,56,93,96, <b>48</b> (6)
Arsenic	—	1.2-1.7	<b>25</b> ,56 (6)	Total DDT	—	1	93 (6)
Mercury	1.8	2.8-11	8 <sup>b</sup> ,25 <sup>b</sup> ,56 <sup>b</sup> ,93 <sup>b</sup> , <b>96</b> , 48 <sup>b</sup> (6)	Arsenic	—	1.2-3.2	8, <b>25</b> ,56,93,96,48 (6)
Nickel	—	1.6	56 (6)	Nickel	—	3.2	56 (6)
				Copper	—	1.6	56 (6)
				Mercury	1.4-3.4	5.4-22	8 <sup>b</sup> ,25,56,93, <b>96</b> ,48 (6)
				Selenium	—	1.0-1.9	8, <b>25</b> ,56,93,96,48 (6)

NOTE: AFC - average fish consumption  
HFC - high fish consumption

- - value less than 1.0

**Bold** indicates site with highest HQ  
nd - not determined

<sup>a</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam; 25 - Hood River; 48 - Yakima River; 56 - Klickitat River; 93 - Snake River; 96 - Clearwater River.

<sup>b</sup> HFC only

## Cancer Risk Estimates

Cancer risks were estimated for general public and Columbia River Basin Native American adults at both 30- and 70-year exposure durations. Cancer risk estimates for detected carcinogenic

chemicals at each sampling site are presented in Appendix I. Total cancer risk estimates are presented in Table 4.3 for each sampling site and for the basin average. Sampling sites were not replicated within a tributary and, therefore, tributary risk estimates were not calculated for fall chinook salmon.

**Table 4.3. Total cancer risks for steelhead**

Consumption Rate/ Exposure Duration	Tissue Type	Total Excess Cancer Risk						Basin Average
		Site <sup>e</sup>						
		8	25	56	93	96	48	
General Public <sup>a,b</sup>								
AFC/30-yr	E	4x10 <sup>-6</sup>	na	na	na	na	na	4x10 <sup>-6</sup>
	FS	6x10 <sup>-6</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	9x10 <sup>-6</sup>	1x10 <sup>-5</sup>
	WB	8x10 <sup>-6</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>	2x10 <sup>-5</sup>	1x10 <sup>-5</sup>	1x10 <sup>-5</sup>
HFC/30-yr	FS	1x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	WB	1x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
AFC/70-yr	E	9x10 <sup>-6</sup>	na	na	na	na	na	9x10 <sup>-6</sup>
	FS	1x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>
	WB	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	3x10 <sup>-5</sup>	4x10 <sup>-5</sup>	2x10 <sup>-5</sup>	3x10 <sup>-5</sup>
HFC/70-yr	FS	3x10 <sup>-4</sup>	6x10 <sup>-4</sup>	5x10 <sup>-4</sup>	4x10 <sup>-4</sup>	6x10 <sup>-4</sup>	4x10 <sup>-4</sup>	5x10 <sup>-4</sup>
	WB	3x10 <sup>-4</sup>	5x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>	7x10 <sup>-4</sup>	4x10 <sup>-4</sup>	6x10 <sup>-4</sup>
Native American <sup>c,d</sup>								
AFC/30-yr	E	3x10 <sup>-5</sup>	na	na	na	na	na	3x10 <sup>-5</sup>
	FS	5x10 <sup>-5</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>
	WB	7x10 <sup>-5</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	1x10 <sup>-4</sup>	8x10 <sup>-5</sup>	1x10 <sup>-4</sup>
HFC/30-yr	FS	3x10 <sup>-4</sup>	7x10 <sup>-4</sup>	6x10 <sup>-4</sup>	5x10 <sup>-4</sup>	7x10 <sup>-4</sup>	5x10 <sup>-4</sup>	6x10 <sup>-4</sup>
	WB	4x10 <sup>-4</sup>	6x10 <sup>-4</sup>	6x10 <sup>-4</sup>	7x10 <sup>-4</sup>	8x10 <sup>-4</sup>	5x10 <sup>-4</sup>	7x10 <sup>-4</sup>
AFC/70-yr	E	8x10 <sup>-5</sup>	na	na	na	na	na	8x10 <sup>-5</sup>
	FS	1x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>
	WB	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>	3x10 <sup>-4</sup>	2x10 <sup>-4</sup>	3x10 <sup>-4</sup>
HFC/70-yr	FS	7x10 <sup>-4</sup>	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>
	WB	9x10 <sup>-4</sup>	1x10 <sup>-3</sup>	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>	2x10 <sup>-3</sup>	1x10 <sup>-3</sup>	2x10 <sup>-3</sup>

NOTE: AFC - average fish consumption

HFC - high fish consumption

na - not applicable; sample type not analyzed at this site

E - eggs

FS - fillet with skin

WB - whole body

<sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 7.5 g/day, or 1 8-oz meal per month (USEPA 2000).

<sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month (USEPA 2000).

<sup>c</sup> AFC risk based on average consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month (CRITFC 1994).

<sup>d</sup> HFC risk based on 99th percentile consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month (CRITFC 1994).

<sup>e</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam; 25 - Hood River; 48 - Yakima River; 56 - Klickitat River; 93 - Snake River; 96 - Clearwater River.

### **Carcinogenic Chemicals with Estimated Risks At or Above $10^{-5}$**

Cancer risk estimates vary across populations, consumption rates, and exposure levels by constant factors. Chemicals in steelhead (fillet with skin and in whole body samples) with cancer risks at or above  $1 \times 10^{-5}$  are shown for the Columbia River Basin Native American population with average fish consumption rates at a 70-year exposure duration; total cancer risks for all chemicals are also shown (Tables 4.4.1 and 4.4.2). Multiplicative factors used to estimate risk at different exposure parameters and target populations are footnoted in the table. In addition, Appendix I shows individual risk estimates for each detected chemical for all the exposure scenarios used in this risk assessment.

A total of four chemicals were at or above  $1 \times 10^{-5}$  for steelhead, depending on sampling site: arsenic, adjusted Aroclors, PCB 126, and PCB 118. In fillet with skin samples, arsenic was the highest at most sites, except for Site 93 and Site 96 where PCB 126 had the highest risk estimates. Adjusted Aroclors was the second or third highest risk estimate for fillet with skin samples at all sites. In whole body samples, arsenic had the highest risk estimate at Sites 8, 56, and 25; PCB 126 had the highest risk estimate at Site 93 and Site 96; adjusted Aroclors had the highest risk estimate at Site 48. Aroclor 1254 was detected and used in the adjusted Aroclor calculation for all sites and tissue types. Aroclor 1260 was also detected and used at Site 25 and Site 48 for fillet with skin and whole body samples.

**Table 5.4.1. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in**

steelhead, whole body

		Steelhead Wholebody					
		Site					
	Chemical	8	25	48	56	93	96
PCBs	Adjusted Aroclors	3E-05	3E-05	5E-05	3E-05	4E-05	4E-05
	PCB 118						1E-05
	PCB 126	4E-05	3E-05	4E-05	5E-05	8E-05	9E-05
Dioxin/furans	1,2,3,7,8-PeCDD						3E-05
	2,3,4,7,8-PeCDF		2E-05	1E-05	1E-05	2E-05	2E-05
Inorganic	Arsenic	7E-05	1E-04	4E-05	9E-05	6E-05	7E-05
Total Cancer Risk for All Chemicals		2E-04	2E-04	2E-04	2E-04	3E-04	3E-04

**Table 4.4.2. Chemicals with cancer risks at or greater  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in steelhead, fillet with skin**

		Steelhead Fillet w/skin					
		Site					
	Chemical	8	25	48	56	93	96
PCBs	Adjusted Aroclors	2E-05	3E-05	4E-05	3E-05	3E-05	3E-05
	PCB 118						1E-05
	PCB 126		5E-05	4E-05	6E-05	6E-05	8E-05
Dioxin/furans	1,2,3,7,8-PeCDD		1E-05				1E-05
	2,3,4,7,8-PeCDF					1E-05	2E-05
Inorganic	Arsenic	6E-05	1E-04	5E-05	9E-05	5E-05	6E-05
Total Cancer Risk for All Chemicals		1E-04	3E-04	2E-04	2E-04	2E-04	3E-04

NOTE: A blank indicates that this chemical does not have a cancer risk at or above  $1 \times 10^{-5}$  for this tissue type at this site

To estimate risk levels for general population AFC 30-year exposure, divide the cells in this table by 19.64.

To estimate risk levels for general population HFC 30-year exposure, divide the cells in this table by 1.03.

To estimate risk levels for Native American AFC 30-year exposure, divide the cells in this table by 2.34.

To estimate risk levels for Native American HFC 30-year exposure, divide the cells in this table by 0.38

To estimate risk levels for general population AFC 70-year exposure, divide the cells in this table by 8.43

To estimate risk levels for general population HFC 70-year exposure, divide the cells in this table by 0.44

To estimate risk levels for Native American AFC 70-year exposure, divide the cells in this table by 0.16

<sup>a</sup> Site - Waterbody: 8 - located in the Columbia River between the John Day Dam and the McNary Dam;  
25 - Hood River; 48 - Yakima River; 56 - Klickitat River; 93 - Snake River; 96 - Clearwater River.

## ***Appendix P-5 Eulachon***

Eulachon were collected from one site in the Columbia River Basin: 3, located in the Columbia River. Chemical analyses were performed on whole body tissue. The risk estimates characterized in this section are based on average chemical concentrations determined from the three replicate composite samples collected from Site 48. One site was sampled for eulachon and, therefore, tributary and basin risk averages were not calculated.

### **Noncarcinogenic Health Effects**

The potential noncarcinogenic health effects associated with the consumption of whole body eulachon were assessed by calculating hazard quotients for all detected chemicals with oral reference doses (Appendix G). The hazard quotients of chemicals with the same health endpoint were summed to calculate endpoint-specific hazard indices. In addition, the hazard quotients of all detected chemicals were summed to calculate a total hazard index for the site. Table P-5.1 shows the total hazard index for each of the populations evaluated in this risk assessment and the health endpoints that had hazard indices at or above of 1.0.

**Table 5.1. Total hazard indices and noncarcinogenic health endpoints with hazard indices at or above 1.0 for eulachon collected from Site 3, Columbia River**

CONSUMPTION RATE <sup>a</sup> / TISSUE TYPE		HEALTH ENDPOINT	HAZARD INDEX
<b>General Public - Adult<sup>a,b</sup></b>			
AFC	WB	Total HI	0.1
HFC	WB	Total HI	1.6
<b>General Public - Child<sup>a,b</sup></b>			
AFC	WB	Total HI	0.1
HFC	WB	Total HI	2.1

CONSUMPTION RATE <sup>a/</sup>			
TISSUE TYPE		HEALTH ENDPOINT	HAZARD INDEX
Native American - Adult <sup>c,d</sup>			
AFC	WB	Total HI	0.4
HFC	WB	Cardiovascular	1.7
		Hyperpigmentation/keratosis	1.7
		Total HI	4.4
Native American - Child <sup>c,d</sup>			
AFC	WB	Total HI	1.3
HFC	WB	Cardiovascular	3.2
		Hyperpigmentation/keratosis	3.2
		Total HI	8.6

NOTE: AFC - average fish consumption      HI - hazard index  
HFC - high fish consumption      WB - whole body

<sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public (adult) of 7.5 g/day, or 1 8-oz meal per month, and for general public (child) of 2.83 g/day, or 0.4 8-oz meal per month (USEPA 2000).

<sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month, and for general public (child) of 77.95 g/day, or 11 8-oz meals per month (USEPA 2000).

<sup>c</sup> AFC risk based on average consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month, and for child fish consumers of 24.8 g/day, or 3 8-oz meals per month (CRITFC 1994).

<sup>d</sup> HFC risk based on 99th percentile consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month, and for child fish consumers of 162 g/day, or 22 8-oz meals per month (CRITFC 1994).

Up to two health endpoints exceeded a hazard index of 1.0, depending on the target population and exposure parameters used for calculation. The two endpoints were cardiovascular and hyperpigmentation/keratosis.

### Chemicals With Hazard Quotients At or Above 1.0.

Individual chemicals with a hazard quotient greater than 1.0 in whole body samples of eulachon at Site 3 were identified and are presented in Table 5.2. Hazard quotients for all individual chemicals are presented in Appendix G. One chemical, arsenic, had a hazard quotient above 1.0 in whole body samples of eulachon at the Native American adult and child, high fish consumption rates.

**Table 5.2. Chemicals having hazard quotients at or greater than 1.0 in eulachon**

ADULTS				CHILDREN			
TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)	TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)
	AFC	HFC			AFC	HFC	
Native American							
Whole body							
Arsenic	–	1.7	3 (1)	Arsenic	–	3.2	3 (1)

NOTE: AFC - average fish consumption

HFC - high fish consumption

– - value less than 1.0

<sup>a</sup> Site - Waterbody: 3 - Columbia River.

## Cancer Risk Estimates

Cancer risks were estimated for general public and Columbia River Basin Native American adults at both 30- and 70-year exposure durations. Cancer risk estimates for detected carcinogenic chemicals are presented in Appendix I. Total cancer risk estimates are presented in Table 5.3. One site was sampled for eulachon and, therefore, tributary and basin risk were not calculated.

**Table 5.3. Total cancer risks for eulachon collected at Site 3, Columbia River**

CONSUMPTION RATE/ EXPOSURE DURATION	TISSUE TYPE	TOTAL EXCESS CANCER RISK
<b>General Public<sup>a,b</sup></b>		
AFC/30-yr	WB	1x10 <sup>-5</sup>
HFC/30-yr	WB	2x10 <sup>-4</sup>
AFC/70-yr	WB	2x10 <sup>-5</sup>
HFC/70-yr	WB	5x10 <sup>-4</sup>
<b>Native American<sup>c,d</sup></b>		
AFC/30-yr	WB	9x10 <sup>-5</sup>
HFC/30-yr	WB	6x10 <sup>-4</sup>
AFC/70-yr	WB	2x10 <sup>-4</sup>
HFC/70-yr	WB	1x10 <sup>-3</sup>

NOTE: AFC - average fish consumption  
HFC - high fish consumption

WB - whole body

- <sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 7.5 g/day, or 1 8-oz meal per month (USEPA 2000).
- <sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month (USEPA 2000).
- <sup>c</sup> AFC risk based on average consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month (CRITFC 1994).
- <sup>d</sup> HFC risk based on 99th percentile consumption rate for fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month (CRITFC 1994).

### Carcinogenic Chemicals with Estimated Risks At or Above $10^{-5}$

Cancer risk estimates vary across populations, consumption rates, and exposure levels by constant factors. Chemicals in eulachon whole body samples with cancer risks at or above  $1 \times 10^{-5}$  are shown for the Columbia River Basin Native American population with average fish consumption rates at a 70-year exposure duration; total cancer risk for all chemicals are also shown (Table 5.4). Multiplicative factors used to estimate risks at different exposure parameters and target populations are footnoted in the table. In addition, Appendix I shows individual risk estimates for each detected chemical for all the exposure scenarios used in this risk assessment.

Only three chemicals had cancer risks above  $1 \times 10^{-5}$  for eulachon: arsenic, 2,3,7,8-TCDD, and 1,2,3,7,8-PeCDD.

**Table 5.4. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in eulachon, whole body collected at Site 3, Columbia River**

		Eulachon - Whole Body
		Site
		3
Dioxin/furans	1,2,3,7,8-PeCDD	3E-05
	2,3,7,8-TCDD	1E-05
Inorganic	Arsenic	1E-04



NOTE: A blank indicates that this chemical does not have a cancer risk at or above  $1 \times 10^{-6}$  for this tissue type at this site.

To estimate risk levels for general population AFC 30-year exposure, divide the cells in this table by 19.64.

To estimate risk levels for general population HFC 30-year exposure, divide the cells in this table by 1.03.

To estimate risk levels for Native American AFC 30-year exposure, divide the cells in this table by 2.34.

To estimate risk levels for Native American HFC 30-year exposure, divide the cells in this table by 0.38

To estimate risk levels for general population AFC 70-year exposure, divide the cells in this table by 8.43.

To estimate risk levels for general population HFC 70-year exposure, divide the cells in this table by 0.44.

To estimate risk levels for Native American AFC 70-year exposure, divide the cells in this table by 0.16.

## Appendix P-6 Pacific Lamprey

Pacific lamprey were collected from two sites in the Columbia River Basin: 21, Willamette River and 24, Fifteen Mile Creek. Chemical analyses were performed on fillet with skin and whole body samples of fish collected from Site 21 and on whole body samples of fish collected from Site 24. The risk estimates characterized in this section are based on average chemical concentrations determined from 3 replicate composite samples collected from each site except for whole body samples at Site 21, which had 6 replicate composite samples (Appendix A). Data are presented at two spatial scales: site and basin. Pacific lamprey were not collected from replicate sampling sites within a tributary and, therefore, tributary risk estimates were not calculated.

### Noncarcinogenic Health Effects

The potential noncarcinogenic health effects associated with the consumption of fillet with skin and whole body Pacific lamprey were assessed by calculating hazard quotients for all detected chemicals with a oral reference dose (Appendix G). The hazard quotients with the same health endpoint were summed to calculate endpoint-specific hazard indices. In addition, the hazard quotients of all detected chemicals were summed to calculate a total hazard index for the site or basin. Table 6.1 shows the total hazard index for each of the target populations evaluated in this risk assessment and the health endpoints which exceeded a value of 1.0.

**Table 6.1. Total hazard indices and noncarcinogenic health endpoints at or above 1.0 for Pacific lamprey**

CONSUMPTION RATE <sup>a</sup> / TISSUE TYPE      HEALTH ENDPOINT			HAZARD INDEX		
			SITE <sup>e</sup>		BASIN AVERAGE <sup>f</sup>
			21	24	
<b>General Public - Adult<sup>a,b</sup></b>					
AFC	FS	Total HI	0.5	na	0.5
AFC	WB	Total HI	0.6	1.0	0.8
HFC	FS	Immune system	8.8	na	8.8
		Total HI	10	na	10
HFC	WB	Central nervous system	1.8	3.6	2.4
		Immune system	8.7	13	10
		Reproduction /development	1.8	3.6	2.4
		Total HI	12	19	14
<b>General Public - Child<sup>a,b</sup></b>					
AFC	FS	Total HI	0.5	na	0.5
AFC	WB	Total HI	0.6	0.9	0.7
HFC	FS	Immune system	11	na	11

CONSUMPTION RATE <sup>a</sup> / TISSUE TYPE			HAZARD INDEX		
			SITE <sup>e</sup>		BASIN
			21	24	AVERAGE <sup>f</sup>
		Total HI	13	na	13
HFC	WB	Liver	–	1.2	1.0
		Central nervous system	2.2	4.6	3.0
		Immune system	11	17	13
		Reproduction /development	2.2	4.6	3.0
		Total HI	15	24	19
<b>Native American - Adult<sup>c,d</sup></b>					
AFC	FS	Immune system	3.9	na	3.9
		Total HI	4.5	na	4.5
AFC	WB	Central nervous system	–	1.6	1.0
		Immune system	3.8	5.9	4.7
		Reproduction /development	–	1.6	1.0
		Total HI	5.3	8.2	6.4
HFC	FS	Liver	2.0	na	2.0
		Immune system	24	na	24
		Total HI	28	na	28
HFC	WB	Liver	1.7	2.6	2.0
		Central nervous system	4.8	9.8	6.5
		Immune system	24	36	29
		Reproduction /development	4.8	9.8	6.4
		Total HI	33	51	40
<b>Native American - Child<sup>c,d</sup></b>					
AFC	FS	Immune system	7.2	na	7.2
		Total HI	8.2	na	8.2
AFC	WB	Central nervous system	1.4	2.9	1.9
		Immune system	7.0	11	8.5
		Reproduction /development	1.4	2.9	1.9
		Total HI	9.8	15	12
HFC	FS	Liver	4.0	na	4.0
		Cardiovascular	1.1	na	1.1
		Immune system	47	na	47
		Hyperpigmentation/keratosis	1.1	na	1.1
		Total HI	54	na	54
HFC	WB	Liver	3.3	5.1	4.0
		Kidney	1.5	–	1.2
		Cardiovascular	1.1	–	0.9
		Central nervous system	9.3	19	12
		Immune system	46	70	56
		Reproduction /development	9.3	19	12
		Hyperpigmentation/keratosis	1.1	–	0.9
		Selenosis	1.3	1.2	1.2
		Total HI	64	99	77

NOTE: AFC - average fish consumption      na - not applicable; sample type not      FS - fillet with skin  
HFC - high fish consumption      analyzed at this site      WB - whole body  
HI - hazard index      -- indicates health endpoint <1.0 at  
that site

- <sup>a</sup> AFC risk based on average U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public (adult) of 7.5 g/day, or 1 8-oz meal per month, and for general public (child) of 2.83 g/day, or 0.4 8-oz meal per month (USEPA 2000).
- <sup>b</sup> HFC risk based on 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish for general public of 142.4 g/day, or 19 8-oz meals per month, and for general public (child) of 77.95 g/day, or 11 8-oz meals per month (USEPA 2000).
- <sup>c</sup> AFC risk based on average consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 63.2 g/day, or 9 8-oz meals per month, and for child fish consumers of 24.8 g/day, or 3 8-oz meals per month (CRITFC 1994).
- <sup>d</sup> HFC risk based on 99th percentile consumption rate for adult fish consumers in the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin of 389 g/day, or 53 8-oz meals per month, and for child fish consumers of 162 g/day, or 22 8-oz meals per month (CRITFC 1994).
- <sup>e</sup> Site - Waterbody: 21 - Willamette River ; 24 - Fifteen Mile Creek
- <sup>f</sup> Basin average hazard indices equals Site 21 hazard indices for FS samples.

Up to eight health endpoints exceeded a hazard index of 1.0 depending on the target population and exposure parameters used for calculation. The eight health endpoints were immune system, central nervous system, reproduction/development, liver, kidney, selenosis, cardiovascular, and hyperpigmentation/keratosis in decreasing order of toxicity based on basin average hazard indices of whole body samples.

### Chemicals With Hazard Quotients At or Above 1.0

Individual chemicals with a hazard quotient at or above 1.0 in fillet with skin samples of Pacific lamprey at Site 21 and in whole body samples at Sites 21 and 24 are shown in Table 6.2. Hazard quotients for all chemicals are presented in Appendix G. A total of three individual chemicals had hazard quotients above 1.0 in fillet with skin samples of Pacific lamprey: total Aroclors, total DDT, and arsenic, in decreasing order of toxicity based on the Native American child, high fish consumption rate. A total of eight individual chemicals had hazard quotients at or above 1.0 in whole body samples of Pacific lamprey: total Aroclors, mercury, total DDT, copper, cadmium, selenium, chlordane (total), and arsenic, in decreasing order of toxicity based on the Native American child, high fish consumption rate. Total Aroclors were comprised of Aroclor 1254 in fillet with skin samples and Aroclor 1254 and Aroclor 1260 in whole body samples.

**Table 6.2. Chemicals having hazard quotients at or above 1.0 in Pacific lamprey**

ADULTS				CHILDREN			
TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES WITH VALUES >1 (total # of sites)	TISSUE TYPE/ CHEMICAL	HAZARD QUOTIENT		SITES <sup>a</sup> WITH VALUES >1 (total # of sites)
	AFC	HFC			AFC	HFC	
<b>General Public</b>							
<b>Fillet with skin</b>							
Total	–	8.8	21 (1)	Total	–	11	21 (1)
Aroclors				Aroclors			
<b>Whole body</b>							
Total	–	8.7-13	21, <b>24</b> (2)	Total	–	11-17	21, <b>24</b> (2)
Aroclors				Aroclors			
Mercury	–	1.8-3.6	21, <b>24</b> (2)	Mercury	–	2.2-4.6	21, <b>24</b> (2)
<b>Native American</b>							
<b>Fillet with skin</b>							
Total	3.9	24	21 (1)	Total	7.2	47	21 (1)
Aroclors				Aroclors			
Total DDT	–	1.0	21 (1)	Total DDT	–	2.0	21 (1)
				Arsenic	–	1.1	21 (1)
<b>Whole body</b>							
Total	3.8-5.9	24-36	21, <b>24</b> (2)	Total	7.0-11	46-70	21, <b>24</b> (2)
Aroclors				Aroclors			
Total DDT	–	1.4	24 (2)	Chlordane	–	1.2	24 (2)
				(total)			
Mercury	1.6	4.8-9.8	21 <sup>b</sup> , <b>24</b> (2)	Total DDT	–	1.5-2.6	21, <b>24</b> (2)
				Arsenic	–	1.1	21 (2)
				Cadmium	–	1.5	21 (2)
				Copper	–	1.3-1.5	21, <b>24</b> (2)
				Mercury	1.4-2.9	9.3-19	21, <b>24</b> (2)
				Selenium	–	1.2-1.3	21, <b>24</b> (2)

NOTE: AFC - average fish consumption  
HFC - high fish consumption

– - value less than 1.0

**Bold** indicates site with highest HQ

<sup>a</sup> Site - Waterbody: 21 - Willamette River ; 24 - Fifteen Mile Creek

<sup>b</sup> HFC only

## Cancer Risk Estimates

Cancer risks were estimated for general public and Columbia River Basin Native American adults at both 30- and 70-year exposure durations. Cancer risk estimates for detected carcinogenic chemical at each sampling site are presented in Appendix I. Total cancer risk estimates are presented in Table 6.3 for each sampling site and for the basin average. Sampling sites were not replicated within a tributary and, therefore, tributary risk estimates were not calculated for Pacific lamprey.

**Table 6-3. Total cancer risk for Pacific lamprey**



risk at different exposure parameters and target populations are footnoted in the table. In addition, Appendix I shows individual risk estimates for each detected chemical for all the exposure scenarios used in this risk assessment.

A total of 12 chemicals had cancer risks at or above  $1 \times 10^{-5}$  in whole body Pacific lamprey: adjusted Aroclors, PCB 105, PCB 114, PCB 118, PCB 126, 1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, arsenic, total chlordane, hexachlorobenzene, and DDE. **Fillet with skin had 11 chemicals with estimated risks at or above  $1 \times 10^{-5}$  - all those for whole body except PCB 114. PCB 126 had the highest risk estimate for both sites and tissue types. Adjusted Aroclors had the second highest risk estimate for both sites and tissue types. The individual Aroclors detected and used in the adjusted Aroclor calculation were Aroclor 1254 for whole body samples at Site 24 and fillet with skin samples at Site 21 and Aroclors 1260 and 1254 for whole body samples at Site 21. Arsenic had the third highest risk for whole body samples at Site 21. PCB 118 had the third highest risk for whole body samples at Site 24 and fillet with skin samples at Site 21.**

**Table 6.4.1. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in Pacific lamprey, whole body**

Pacific Lamprey - Whole Body			
Chemical		Site	
		21	24
PCBs	Adjusted Aroclors	1E-04	2E-04
	PCB 105	1E-05	2E-05
	PCB 114		1E-05
	PCB 118	4E-05	7E-05
	PCB 126	4E-04	4E-04
	PCB 156	2E-05	3E-05
	1,2,3,7,8-PeCDD	2E-05	
Dioxin/furans			

<b>Inorganic Pesticides</b>	<b>2,3,7,8-TCDF</b>	2E-05	4E-05
	<b>Arsenic</b>	4E-05	2E-05
	<b>Chlordane (total)</b>	1E-05	2E-05
	<b>Hexachlorobenzene</b>	1E-05	1E-05
	<b>DDE</b>	1E-05	2E-05
<b>Total Cancer Risk for All Chemicals</b>		<b>6E-04</b>	<b>9E-04</b>

**Table 6.4.2. Chemicals with cancer risks at or above  $1 \times 10^{-5}$  for Columbia River Basin Native American population at average fish consumption and 70-year exposure duration in Pacific lamprey fillet with skin**

		<b>Pacific Lamprey - Fillet w-skin</b>
		<b>Site</b>
	<b>Chemical</b>	<b>21</b>
<b>PCBs</b>	<b>Adjusted Aroclors</b>	1E-04
	<b>PCB 105</b>	2E-05
	<b>PCB 114</b>	1E-05
	<b>PCB 118</b>	5E-05
	<b>PCB 126</b>	2E-04
	<b>PCB 156</b>	2E-05
<b>Dioxin/furans</b>	<b>1,2,3,7,8-PeCDD</b>	2E-05
	<b>2,3,7,8-TCDF</b>	2E-05
<b>Inorganic Pesticides</b>	<b>Arsenic</b>	4E-05
	<b>Chlordane (total)</b>	1E-05
	<b>Hexachlorobenzene</b>	1E-05
	<b>DDT</b>	1E-05
	<b>DDE</b>	2E-05
<b>Total Cancer Risk for All Chemicals</b>		<b>6E-04</b>

NOTE: A blank indicates that this chemical does not have a cancer risk at or above  $1 \times 10^{-5}$  for this tissue type at this site.

To estimate risk levels for general population AFC 30-year exposure, divide the cells in this table by 19.64.

To estimate risk levels for general population HFC 30-year exposure, divide the cells in this table by 1.03.

To estimate risk levels for Native American AFC 30-year exposure, divide the cells in this table by 2.34.

To estimate risk levels for Native American HFC 30-year exposure, divide the cells in this table by 0.38.

To estimate risk levels for general population AFC 70-year exposure, divide the cells in this table by 8.43.

To estimate risk levels for general population HFC 70-year exposure, divide the cells in this table by 0.44.

To estimate risk levels for Native American AFC 70-year exposure, divide the cells in this table by 0.16.

<sup>a</sup> Site - Waterbody: 21 - Willamette River ; 24 - Fifteen Mile Creek



